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Effect of pruning intensities of *Dalbergia sissoo* and different levels of fertilizer dose and seed rate of wheat on carbon sequestration of agrisilviculture based agroforestry system

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Abstract
The present investigation was taken up with 17 years old agrisilviculture system (*Dalbergia sissoo* + wheat) during *Rabi* season 2015-16 under AICRP on Agroforestry, Department of Forestry, JNKVV, Jabalpur (M.P.). Planting space of *Dalbergia sissoo* was 5×5 m. The treatment combination involved four pruning treatments and one open (without tree) in main plot and three levels of fertilizer and seed rate of wheat variety GW-173 in sub plot in split plot design.
Wheat under open condition recorded significantly higher fresh wt., dry wt., fixed carbon and carbon sequestration as compared to no pruning which recorded the lowest values. Fresh wt, dry wt., fixed carbon and carbon sequestration was significantly higher under T_2 (T_1 + 25% more nitrogen than recommended dose) as compared to T_1 treatment.25% pruning recorded higher DBH, tree volume, above ground biomass, carbon sequestration, carbon-di-oxide sequestrated by tree and carbon-di-oxide sequestrated by the tree per year and it was minimum in 75% pruned trees.
Combination of *Dalbergia sissoo* + wheat sown under 25% pruning recorded significantly higher carbon sequestration potential as compared to other pruning treatments.

Keywords: Agrisilvicultural system, carbon sequestration, *Dalbergia sissoo*, wheat

Introduction
Climate change and global warming are the two major worldwide issues that need to be paid attention in the present time. The environmental shift and steady rise in temperature mainly contributes to global warming and is mainly a result of fossil fuel combustion resulting in heavy accumulation of greenhouse gases. Carbon-di-oxide, methane, nitrous oxide and ozone are the common GHG mainly responsible for global warming ultimately affecting the yield potential of crops and trees. CO_2 alone constitutes more than 65% of the total greenhouse gases.
Some of the Carbon emitted is naturally absorbed by plants during photosynthesis. Trees and plants are capable of capturing excess carbon of the atmosphere resulting in enhanced productivity, and also lowering atmospheric temperature because their shade and wind protection reduces energy consumption for heating and cooling buildings. (Francisco Escobedo *et al.* 2010) [3]. In estimating carbon sequestration, researchers accounted for average annual growth for different types of trees in different size classes and in different conditions (Nowak and Crane 2002) [6]. Agroforestry provides resilience to agricultural production under current climatic variability as well as long-term climate change through intensification, diversification and buffering of trees in farming system (Schoeneberger 2009) [7]. The role of Agroforestry in protecting the environment and providing a number of ecosystem services is promoted as a key benefit of integrating trees into farming systems. In agroforestry systems, two major components i.e. trees and crops are mainly responsible for CO_2 sequestration. The total amount sequestrated in each component differs greatly and is dependent largely on a number of factors that includes the type of system (and the nature of components and age of plant), site quality, and previous land-use (Albrecht and Kandji 2003, Newaj and Dhyani 2008) [1, 5].
Agroforestry have carbon storage potential in its numerous plant species and soil, high applicability in agricultural land, and indirect effects such as decreasing pressure on natural

forest or soil erosion (Montagnini 2004 and Nair 2008) [4]. The utilization of the environment by species includes three main components: space, resources, and time. Any species utilizing the same exact combination of these resources as another will be direct competition which could lead to a reduction in C sequestration. Agroforestry component can be a progressive method for sequestering excess carbon of the atmosphere and act as carbon sink resulting in enhanced productivity and better economic status of farmers from limited area. Keeping this in view the present investigation has been conducted under agrisilvicultural system at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, M. P. India

Materials and methods

The present investigation was conducted during *Rabi* season of 2015-16 under All India Co-ordinate Research Project on Agroforestry in dusty acre farm, Department of Forestry, JNKVV, Jabalpur. Jabalpur is situated at 23º98' North latitude and 79º80' East longitude with an attitude of 411.78 meters above the mean sea level. The mean annual rainfall of Jabalpur 1350 mm mostly received between mid-June to end of September with a little and occasional rainfall in remaining part of year. Minimum and maximum mean temperature ranged from 15.3ºC to 44.0ºC, respectively. *Dalbergia sissoo* was planted in 5 × 5 m spacing in the year 1998. The treatment combinations involved five pruning treatments (viz., no pruning, 25%, 50%, 75% pruning from ground level) and one open (crop alone) in main plot and three fertilizer doses and seed rate viz. T_1-Recommended dose of fertilizer and seed rate, T_2– T_1+25% more nitrogen than recommended dose and T_3 – T_1 + 25% more seed rate than recommended dose in sub plot. Wheat variety GW 173 was sown in sub plots. The experiment was laid down in strip plot design with five replications. The soil of experiment was clay loam in texture with pH 6.2, medium in organic carbon (0.45), medium in available nitrogen (206 kg/ha) and high in available phosphorus (20kg/ha) and low in available potash (170 kg/ha). In intercropping wheat variety GW - 173 was sown in 22 cm spacing fertilized with recommended dose of fertilizers (120:60:40 N:P:K kg/ha).The height and diameter at breast height (1.37 m from ground) were measured at seventeen years of tree growth. From these measurements basal area and volume of trees were computed as per formula viz.,

$$\text{Basal area} = 0.00007854 \times (\text{dbh})^2$$

$$\text{Volume of tree} = \text{Basal area} \times \text{Tree height}$$

The sampled trees were felled at the ground level. All the leaves, twigs, branches were removed from the main bole. A 5 cm thick disc of wood sample was collected from main bole. Wheat plants were uprooted from each plot. Fresh wt. of all tree and crop samples was taken. For biomass estimation these samples were properly oven dried at 70^0 C till constant weight. The dried samples were powdered. The powdered samples of wood and wheat crop were burnt in a muffle furnace at 550^0C for 4-6 hours and residue was weighted a ash content. Carbon content in all the samples of tree and crop has been estimated as per the given formula

Carbon sequestration = Biomass × carbon %

From the total dry biomass, total carbon content and amount of CO_2sequestrated in trees was calculated. For calculating CO_2 equivalent, total carbon was multiplied with a factor of 3.6663 on the basis of atomic weight ratio of CO_2 to C. For calculating CO_2 sequestration rate of individual tree species, total CO_2 was divided by age of trees (17 years).

Results and discussion

Carbon sequestration by the crop (Wheat)

In agroforestry systems, although tree sequester more carbon, but crops also fix and store carbon in considerable amounts. Wheat under open condition recorded significantly higher fresh wt., dry wt., fixed carbon and carbon sequestration of the crop, whereas wheat under no pruning recorded significantly lowest fresh wt., dry wt. and fixed carbon and carbon sequestration by the crop. Different pruning intensities showed no significant difference on fixed carbon. In the undercrop sown with *Dalbergia sissoo*, the fresh and dry weight of wheat (gm) and carbon sequestration were significantly higher in the crop sown under pruned 75% *Dalbergia sissoo* trees and fresh weight and carbon sequestered was at par in the crop under 50% and 25% pruned trees. The ash content of the crop was higher in the crop under 50% pruned trees and varied significantly from open crop only.

Different levels of fertilizer dose and seed rate show significant effect on fresh wt., dry wt., ash content and fixed carbon. T_2 i.e. 25% more nitrogen than recommended dose recorded significantly maximum fresh wt, dry wt., ash content and fixed carbon as compared to T_1 (i.e. recommended dose of seed rate and fertilizer dose) and T_3 (i.e. T_1+ 25% more seed rate than recommended dose).

Carbon sequestration by trees

In *Dalbergia sissoo* tree the DBH was significantly higher in unpruned trees which varied significantly from 75% pruned trees, whereas the above ground biomass (t ha^{-1}) was significantly maximum in 25% pruned trees. The tree volume (m^3/tree) and Carbon sequestration in the tree (t ha^{-1})was significantly higher in 25% pruned trees where tree volume of 25% and 50% trees were at par with each other and tree carbon sequestration of 25% pruned trees varied significantly from 75% pruned trees only. Chourasia (2012) reported highest biomass (580 kg/tree) and highest carbon sequestration potential (261 kg C/tree) in *Dalbergia sissoo*. Carbon-di-oxide sequestrated in the tree (t ha^{-1}) and Carbon-di-oxide sequestrated in the tree per year (t ha^{-1}) was significantly higher in 25% pruned trees and at par with unpruned and 50% pruned trees.

Different levels of fertilizer and seed rate did not have significant variations for any of the above parameters recorded.

Carbon sequestration of agrisilviculture system (t ha^{-1})

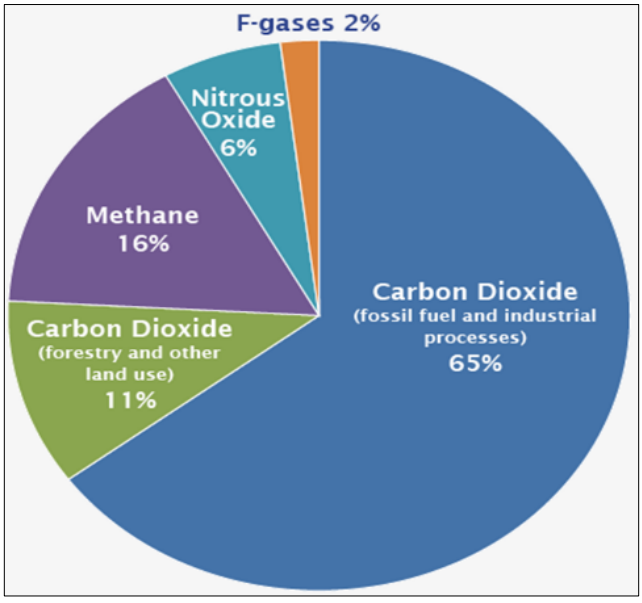
The study (Fig.2&3) revealved that carbon sequestration was significantly higher under managed agroforestry system. 25% pruned *Dalbergia sissoo* sequestered maximum carbon and was at par unpruned trees and 50% pruned trees. The values of were significantly minimum in 75% pruned trees. Different level of fertilizer and seed rate showed no significant effect on carbon sequestration. The carbon sequestration value was significant minimum in open (crop alone).

Table 1: Effect of different pruning intensities in *Dalbergia sissoo* and different level of fertilizer doses and seed rate on carbon sequestration of wheat under agrisilvicultural system

Treatment	Fresh wt. of Wheat (gm)	Dry wt. of Wheat (gm)	Ash content (%)	Fixed carbon %	Carbon sequestration by the crop (t ha^{-1})
A. Pruning intensities					
P_0- No Pruning	87.8	35.6	10.3	30.1	4.7
P_1- 25% Pruning	93.6	39.2	10.9	31.8	5.1
P_2- 50% Pruning	94.8	40.2	12.4	29.3	5.0
P_3- 75% Pruning	98.7	40.5	11.5	30.8	5.4
Open	103.6	43.1	11.6	33.1	6.0
SEM ±	0.94	0.80	0.45	0.84	0.20
CD (P= 0.05)	2.83	2.41	1.35	2.51	0.61
B. Different level of fertilizer dose and seed rate					
T_1– (Recommonded dose of Seed Rate and Fertilizer Dose, control)	89.0	34.8	9.5	26.3	4.54
T_2 – (T_1 + 25% more nitrogen than recommended dose	114.6	45.0	13.4	40.3	6.75
T_3 – (T_1+ 25% more seed rate than recommended dose)	93.5	39.3	11.1	26.3	4.45
SEm±	1.53	0.75	0.72	1.30	0.27
CD (P= 0.05)	4.99	2.44	2.36	4.24	0.88

Table 2: Mean values of carbon sequestration and attributing characters of *Dalbergia sissoo* as influenced by different pruning intensities in *Dalbergia sissoo* + wheat based agrisilvicultural system of agroforestry

Treatment	DBH (cm)	Tree volume (m^3/tree)	Above ground biomass (t ha^{-1})	Carbon sequestration in the tree (t ha^{-1})	CO_2 sequestrated in the tree (t ha^{-1})	CO_2 sequestrated in the tree per year (t ha^{-1})
A. Pruning intensities						
P_0 – No pruning	25.81	0.58	167.10	83.42	305.83	17.99
P_1 – 25% pruning	24.37	0.60	185.92	96.88	355.20	20.89
P_2 – 50% pruning	23.22	0.51	152.16	81.81	299.22	17.64
P_3 – 75% pruning	17.76	0.28	83.28	47.12	172.26	10.16
SEM ±	1.57	0.08	24.30	12.09	39.59	2.33
CD (P= 0.05)	5.03	0.28	77.73	38.66	126.6	7.45
B. Different levels of fertilizer dose and seed rate						
T_1 – Recommended dose of fertilizer and seed rate	23.5	0.52	150.64	80.29	294.00	17.32
T_2 – T_1 + 25% more nitrogen than recommended dose	22.7	0.53	155.92	81.55	299.00	17.59
T_3 – T_1 + 25% more seed rate than recommended dose	22.0	0.46	138.49	73.08	267.92	15.76
Tree alone	22.2	0.46	143.38	74.29	272.37	16.02
SEm±	1.58	0.07	20.80	10.80	136.19	8.01
CD (P= 0.05)	NS	NS	NS	NS	NS	NS



Source: US Government EPA

Fig 1: Global Greenhouse Gas Emissions by Gas

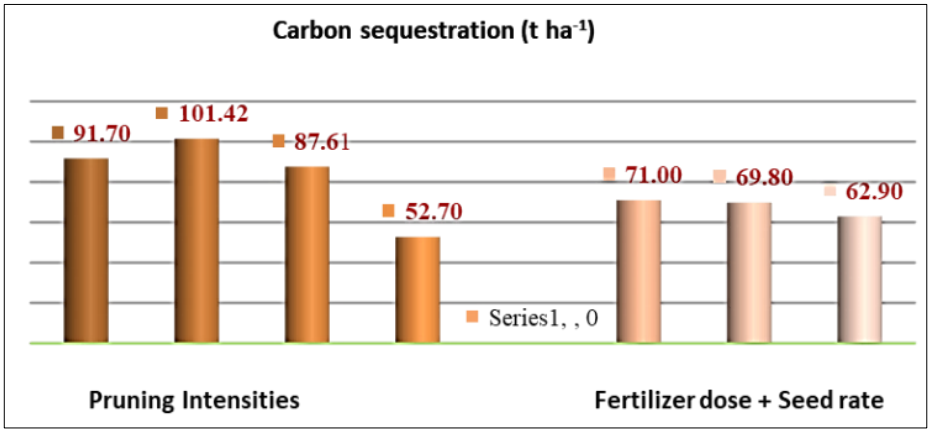


Fig 2: Mean values of carbon sequestration (t ha^{-1}) in *Dalbergia sissoo*+ Wheat (agrisilviculture) based agroforestry system

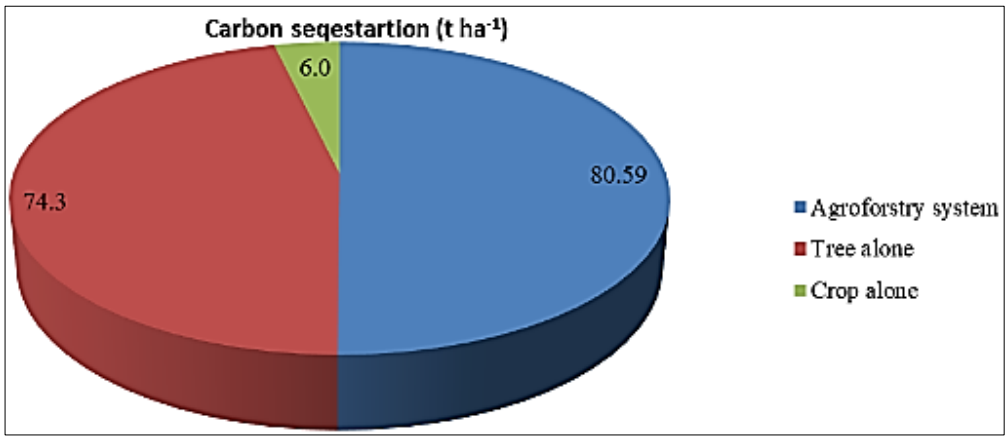


Fig 3: Mean values of carbon sequestartion (t ha $^{-1}$) under different practices

Conclusion

Wheat + *Dalbergia sissoo* (25% pruned) recorded significantly higher carbon sequestration (101.42 t ha^{-1}) as compared to other pruning treatment and no pruning (91.7 t ha^{-1}), tree alone (74.3 t ha^{-1}) and crop alone which recorded the lowest carbon sequestration (6.0 t ha^{-1}) under agrisilviculture system of agroforestry.

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